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## Abstract

Virtual Reality (VR) is a promising alternative for next generation online interface. It is important that the developed VR interfaces must satisfy a collection of good quality criteria, which are still absent from literatures. This paper aims to determine factors consisted in a good quality online VR interface and their relative importance. VR commerce is selected for the study due to its importance. The study employed a two-stage factor identification design. In the first stage, the intuitive approach and the focus group technique were used, while in the second stage, empirical study employing questionnaires were used following by exploratory factor analyses. Then, the derived quality factors were explored for their relative importance on adoption using Analytic Hierarchy Process (AHP). The study outlined 54 recommended interface features/elements forming 8 stable quality factors. The results suggested quality factors for developing and evaluating such a highly interactive user interface.

## Introduction

In this age of the Internet, World-Wide-Web (WWW) is the prominent standard of the Internet applications. The standard is based on the Hypertext Mark-up Language (HTML) that typically combines texts, images, and other media, and presents them to users. Recently, there are promising powerful interfaces emerging as alternatives. Virtual Reality (VR) interface is one of the promising interfaces offering a highly interactive environment. VR is a human-computer interaction technology that lets the users interact with the computer simulated environment. The generated environment can be an environment of either a real world or an imaginary world. This VR environment, as well as similar 3D virtual world, has been introduced into and studied in many application areas, such as entertainment, e.g. SecondLife [1]; medical and education [2, 3]; e-commerce [4-8]; tourism, e.g. Thai Royal Palaces Virtual Tour [9]; etc. Such highly interactive interface contains several distinct characteristics from general HTML web interface. It has been proven that it can offer superior experiences for certain tasks [4-6].

Among VR applications, VR commerce can be a potential candidate for wide adoption since its importance and advantages derived from VR interface. E-commerce becomes a common practice for trading. The huge market size and expanding trend intensify its pivotal role in local and global trading. In the United States alone, the retail sales on e-commerce reached at least 31.72 billion dollars in only a period of a quarter in the first quarter of 2009 [10]. There are several e-commerce growth limitations. One of them is the e-commerce interface limitation. The e-commerce user interface limits the interaction between users and products, thus helping users acquire knowledge about products in such limitation is challenged, especially for particular types of products that require a high degree of interaction between consumers and products or services, e.g. a mobile phone that consumers would like to feel touch and use its features, a hotel room that the prospective guest might want to virtually walk around the room, etc. VR could be a solution. VR commerce customers will be able to get more insight into the product features leading to purchase intention, which has been presented in Lu [5] and Suh [11].

However, to achieve such highly interactive experiences in VR interface, the construction of virtual environments is considered to be more costly than general web interfaces. It is important that the developed VR interfaces should satisfy a collection of good quality criteria. Moreover, the evaluation of the system implementation success is a suggested critical practice for adopting an information system. Such criteria and measure for a good quality online VR interface is not yet available in literatures.

This study is among early research contributing in VR interface quality. It aimed to determine factors the users preferred for an online VR interface, which we refer as good quality factor. VR commerce interface or VR store was selected for this exploratory study due to its importance, adoption potential, as previously mentioned, and also availability.

This paper is organized as follows. Background and theories are introduced in the next section. It is followed by the research methodology in the third section. Results and discussion are provided next in the fourth section. The last section, conclusion and future works, wraps up the main ideas presented and provides suggestions for future research.

## Background and Theories

In this section, related theories and literatures are reviewed in the following order of topics: Virtual Reality (VR), Virtual Reality Commerce (VR-commerce), web quality and Analytic Hierarchy Process (AHP).

### Virtual Reality

Virtual reality (VR) is a human-computer interaction technology that let the users interact with the computer simulated environment [12]. The generated environment can be either a real world or an imaginary world. To imitate the real-world experience, special visual devices are used, such as mask, wall-projected room, and so on. Nonetheless, common monitors can be used to provide a certain level of VR experience. Generally, VR in computer screen generates environments that the users found themselves submersed into the environment. Users can use special input device or a common keyboard and mouse to interact with the environment.

The ability of virtual reality to enhance the consumer abilities is based on three main properties: high media richness, interactivity and telepresense [11]. Media richness theory [13] claims that high uncertainty or ambiguity tasks need higher interaction or higher media richness to reduce the uncertainty or ambiguity. In this case, VR can provide such high media richness through the interactivity. Such interactivity is achieved when the e-commerce site users manipulate the product and immediately get the information regarding the product features and appearance [14, 15]. Through VR, users can feeling the existing of telepresence [14, 16], which indicates a sense of "being there," in the remote environment through a mean of communication [17]. In this sense, we might expect telepresense-related quality factors to emerge from the study in addition to the quality factors for typical web interface.

### Virtual Reality Commerce

Virtual reality commerce or VR-commerce is a type of e-commerce. The major difference of this type of e-commerce from general e-commerce sites is that its user interface is presented in a virtual reality manner. The VR-commerce site can incorporate VR capability. We can say that, in general, a VR-commerce site looks like a virtual shopping mall which users walk around a simulated shopping mall as they immerse into the screen. Thus, the interfaces are presented in three dimensions or 3D. Figure 1 shows an example of a VR-commerce website. General VR-commerce sites try to provide user interfaces that the users will get shopping experiences as realistic as possible. VR-commerce is getting attention from researchers and business practitioners because of its uniqueness and abilities which former types of e-commerce cannot accomplish. There are various ways for the

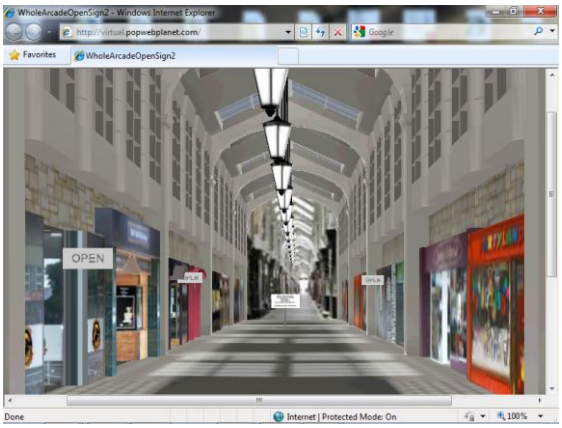


Figure 1 - A Virtual Shopping Mall (http://virtual.popwebplanet.com)

VR-commerce customers to interact with a VR-commerce system.

### Web Quality

Web interface is one of the most prominent online interfaces of the era. The shifting of information system technology from the primitive years of standalone, PC-based computers and mainframes triggered a handful of framework or guideline proposals for good quality webs as explained in [18, 19], for example. As discussed, the superiority of VR interface could be a promising alternative for online interfaces. The study of determining good quality factors for this highly interactive interface can follow the studies or research in web quality.

This study started by employing an intuitive approach, which provided advantages over theoretical approach in this kind of exploratory research; the VR interface quality factors were identified by users and the researchers rather than from theoretical literatures. Nonetheless, it is worthwhile to review major web quality dimensions.

According to an extensive review and analysis by Aladwani and Palvia [18], web quality consisted of four major dimensions: appearance, specific content, content quality and technical adequacy. Only the user interface was our focus in this study, we roughly expected that the emerging factors should be more correlated with the dimensions of appearance and technical adequacy, along with unidentified factors exclusively for online VR commerce interface rather than content dimensions.

### Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) is a technique dealing with complex decisions; it was introduced by Thomas L. Saaty [20, 21]. The technique is one of popular techniques in decision support tasks. Study in [22] provides a comprehensive review of research and applications using AHP. The basic principle of the technique is based on the calculation of complete

pairwise combination comparisons towards the goal of all of decision criteria.

For example, *brand, price and appearance* can be criteria for decision making in buying a car. The weighted priorities of each criterion can be calculated by calculating ratings on all combination of pairwise comparisons of criteria, i.e. brand over price, brand over appearance and price over appearance. Example of calculated weighted priorities could be 30%, 50% and 20% for brand, price and appearance, respectively. Each criterion can have sub criteria. Then, it is possible to use these weights to make optimal decisions among available choices, which are cars in this example. In brief, each car in the shopping list will be rated for the criteria, and then these ratings and the previously derived weights will be used to determine the final scores of choices. More explanation can be found in [20].

In this study, we used AHP to calculate the priority weights referring to the goal of adopting VR commerce for shopping.

## Research Methodology

The objectives of the study were to investigate:

1) What were quality factors of the VR interface that users expected?
2) What were the relative important orders of those quality factors for the adoption of the VR commerce interface?

To answer these two research questions, a two-stage design was used.

### Research Design

#### *The Two-Stage Study*

The study tried to discover interface quality factors lacking from literatures, it required a study in an exploratory manner. Moreover, the quality factors of VR interface were expected to be moderately novel and abstract to general users, thus the study started by the identification of user interface's component in the feature and element level, in the first stage of the study. Then, those interface features/elements were used as inputs for the second phase of the study attempting to identify emerging quality factors.

In each stage, it is possible to determine interface features, elements or quality factors of a user interface by following three alternative approaches in comparable studies [18, 23]. The approaches are: 1) intuitive, 2) theoretical, and 3) empirical approach. The intuitive approach is appropriate for the first stage of the study where the identification of quality features or elements is based on researchers' experiences or intuitive understanding of the users [23]. The empirical approach was employed in order to categorize the derived interface features/elements from the first stage into quality factors. The data collection and analyses were more extensive in the second stage.

#### *First Stage: Preferred Features/Elements*

The focus group method was used in the intuitive interface features/elements exploration. Two weeks before the sessions, the participants were introduced to several VR commerce interfaces, such as the one shown in Fig. 1, as well as other VR interfaces, e.g. the 360 degree view of car or house selling websites and so on. VR and 3D interface of the following websites were shown: secondlife.com, virtual.popwebplanet.com, lh.co.th, sansiri.com, lexus.com, samsung.com. The participants were also asked to get familiar with the VR interface by installing a VR shell created by Phosaard and Tanthanuch [24] replacing their desktop for a week.

Two separate sessions of the focus group were conducted to verify the results. In each session, each respondent were asked to identify as many as possible features or interface elements of general VR commerce interface. Then the participants were asked to work in a group of three to combine their items. The participants were told that the team that come up with the most complete list, without redundant items, will get a 100 Baht-worth rewards. Finally, ten lists from ten teams were shown to the whole session. Then, the participants were asked to work as a whole to combine those lists into only one list. The second session performed the same but the participants were asked to combine the list from the first session at the end. Each session lasted around 1 hour and a half.

#### *Second Stage: Categorization & Relative Importance*

A self-report questionnaire was used for an empirical study of good quality factors. Similar to the first stage, the respondents were introduced to several VR commerce interfaces, as well as other VR, however, only a week in advanced. The participants also asked to get familiar with the VR interface by installing the VR shell created by Phosaard and Tanthanuch [24] replacing their desktop for a week. The study then followed by applying statistical analyses on the collected data. Descriptive statistics, factor analyses, as well as other related statistics were applied until a stable and meaningful factors emerged from the data collected.

In the second stage, the relative important of factors were also analyzed to gain more insight into users' preferences. The Analytic Hierarchy Process (AHP) was used to investigate such complex relations.

### Research Instrument

A questionnaire survey was developed mainly for the second stage of the study. The self-report questionnaire consists of two parts. The first part contains six personal information questions: two questions for demographic information, which are 1) gender and 2) age; four questions for related computer usage and experiences: 3) computer usage experience, 4) computer usage per day, 5) virtual reality

application/game usage experience, and 6) e-commerce shopping experience.

The second part of the survey contains 54 VR interface features/elements derived from the first stage of the study. The respondents were asked to rate the importance of the features/elements in general VR commerce interface on a 5-Likert scale from extremely important (5) to extremely not important (1). The extremely important rating was selected if the respondents find that those features/elements are required for the adoption of such interface.

For relative importance of factors on the adoption of VR interface using AHP, the quality factors derived from factor analyses were put into a hierarchical decision model and a pairwise comparison questionnaire was used. The participants were asked to rate their relative importance for each pair of the quality factors, and features/elements in each factors.

**Participants**

For both stages, research participants and respondents can be general computer users with good understanding of VR commerce interface but expertise on it was not required. Undergraduate students were able to be the targets. In the first stage, there were 30 participants in each session, totaling 60 participants. All of them were third year undergraduate students in Information Technology major registering for either a Web Application or an E-Business class in a university in the northeastern of Thailand.

In the second stage, 144 questionnaire respondents were mostly second year undergraduate students in IT major, aged 18-23, registering for a Web Technology class. 71.5% of them are female while 28.5% are male. They had average computer usage experiences of 8.69 years, and use computer on an average of 8.68 hours per day. 13.3% of the respondents never had experience with virtual reality applications or games before we introduced the interfaces while 76.7% already had. 85.9% used to shop or look for product information online while 14.1% did not.

Selected from the second stage participants, 35 of them completed the pairwise comparisons questionnaire for AHP.

## Results and Discussion

**First Stage**

Repeated focus groups during the first stage of the study outlined 54 preferred features/elements of VR commerce interface. The results are listed, not in priority order, in Table 1. The items were then categorized by the empirical study in the second stage.

**Second Stage**

The questionnaire was then used for the empirical survey study in the second stage. The 54-item instrument was distributed to students, mostly second year students, aged between 18-23 years.

To identify VR interface quality factors we followed Churchill's [25] recommendations for scale development process, which consisted of design and normalization phase. We did not perform a normalization phase since the purpose was to identify stable factors, not the instrument. We started by computing an overall reliability coefficient of the instrument from the collected data using Cronbach's alpha. In this study, we considered VR interface quality as one construct consisting of correlated subcontracts, thus a Cronbach's alpha for the whole items was calculated. The value computed was 0.932. By maintaining Churchill's recommendations discarding items that showed very low corrected item-total correlations, i.e. <0.40 can improve reliability. After several screening attempts, 32 items remained on our list.

Next, factor analyses were applied on the 32-item list to discover sub constructs or factors, which was the main study objective. Before applying factor

Table 1 – Preferred features/elements of online virtual reality commerce interface—first stage

| | | |
|---|---|---|
| event synchronization | seasonal activities | cashier's avatar |
| imagination elements | ability to travel outside the store | animated elements |
| product trial | well-known landmark elements | customer's avatar |
| zoom-in/out capability | overall reality | emotional expression of avatar |
| product appearance's details | touch screen interface capability | decorative elements |
| games | direct searching for products | layout familiarity |
| innovative elements | scenic viewpoints | proper product size |
| proper use of colors | proper use of fonts | chat functionality |
| product department familiarity | proper use of camera's view | the smoothness of VR control |
| proper store size | shopping cart functionality | proper use of sound effects and ambient sounds |
| attractiveness | speed of VR loading | mouse-control enable |
| store navigation's map | proper use of music | product completeness |
| natural ambience | stability of the VR interface | the use of visual effects for interface' attractiveness |
| reality details of the store | speed-up navigation capability | real-world motion, e.g. object impassable motion |
| time synchronization | interface element customization | proper use of control's speed |
| cashier counter | explanation for each location | putting similar department in the same area |
| not induce dizziness | virtual restaurant | proper product categorization in the department |
| elevator | layout customization | natural responsiveness of the control |

analysis, required statistical tests were performed for the validity of the results. Kaiser-Meyer-Olkin (KMO) index was calculated and Bartlett's test of sphericity was performed. The KMO index is used as a measure of sampling adequacy. Generally, high value of this index, value higher than 0.5 and close to 1.0 indicates that the factor analysis is suitable. Barlett's test of sphericity is used to test whether inter-correlations among variables exist. There should be significant inter-correlations among interface features/elements to form interface quality factors.

For our data, the KMO index was 0.895 and the Bartlett's test of shpericity yielded a Chi-Square value of 1980.296 and a significance value of 0.000 indicating that the data obtained was appropriate for factor analysis.

Then, the next process started by submitting the items for factor analysis with varimax rotation. Items which loaded equally on more than one factor or not substantially loaded on one factor resulted in ambiguity of factor interpretation; such items should be eliminated. Hair et al. [26] suggested that the items with factor loadings > 0.30 are considered significant, > 0.40 are more important, and > 0.50 are considered very significant. There are no absolute standard of the cut-off value. Based on the purpose of the study, to identify stable and meaningful interface quality factors, and similar work, e.g. the study of web quality [18], items that did not meet the loading cut-off of 0.50 or ambiguously loaded on more than one factors were eliminated. The remained items were resubmitted for another round of factor analysis. The process iterated until a meaningful structure was achieved. The results are shown in Table 2.

Table 3 summarizes the final results of the factor analysis. The table shows emerging quality factors of online VR commerce interface along with their associated interface features/elements. Each emerging factor was analyzed and given a name reflecting its meaning according to the item members. Cronbach's alpha coefficients for each quality factor were calculated to confirm the reliability and the internal consistency of the discover factors. Generally, 0.7 is the cut-off alpha value for factors establishing reliability. Nonetheless, it is widely accepted that 0.6 is acceptable for exploratory research [27]. Thus, all of the factors showed internal consistency. It is noted that the *Content Finding* is a one-item separated factor emerging by forcing the number of factors to 8, according to the scree plot, creating a meaningful structure.

It is possible to compare factor importance priority by their means. However, it is more meaningful and useful to examine the priority of the derived quality factors over the adoption of VR Commerce on their relative importance. We used AHP to systematically assess this. Firstly, the decision model can be built by determining the goal as the "Use of VR Commerce Interface for Shopping," then the first level of the decision model was consisted of the derived quality factors. All of each node of the quality factors was consisted of items in their factors forming the second level of the decision model. The results from pairwise comparisons from the participants were put into the AHP calculation and the weighted priorities of each item are shown in the "Priority Weight" in Table 3.

Table 2 – Principal component analysis with varimax rotation—second stage

| **Interface Features/Elements** | **Component** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| Event synchronization | .849 | .071 | .146 | .150 | .184 | .019 | .167 | .011 |
| Seasonal activities | .816 | .142 | .054 | .066 | .236 | .073 | .099 | .155 |
| Cashier's counter | .677 | .389 | -.059 | .104 | -.115 | .022 | .222 | .230 |
| Elevator | .620 | .130 | .172 | .247 | .008 | .311 | .059 | -.364 |
| Innovative elements | .026 | .727 | .217 | -.011 | .120 | .169 | .160 | .147 |
| Decorative elements | .238 | .709 | .202 | .258 | .051 | .029 | -.025 | .113 |
| Scenic viewpoints | .368 | .661 | -.041 | .201 | .209 | .054 | -.005 | -.189 |
| Animated elements | .082 | .142 | .753 | .171 | .299 | -.080 | .166 | .003 |
| Overall reality | .194 | .032 | .689 | .097 | .106 | .308 | -.089 | .316 |
| Touch screen interface capability | -.010 | .309 | .643 | .047 | .037 | .144 | .366 | -.183 |
| Layout familiarity | .212 | .147 | .133 | .892 | .061 | .041 | .066 | .030 |
| Product department familiarity | .110 | .144 | .083 | .867 | .017 | .088 | .225 | .033 |
| Proper use of colors | .153 | .111 | .344 | -.006 | .774 | -.047 | .058 | .089 |
| Proper use of fonts | .121 | .048 | .238 | .049 | .696 | .200 | .044 | .374 |
| Layout customization | .148 | .356 | -.236 | .116 | .617 | .196 | .356 | -.076 |
| Proper use of camera's view | .074 | .017 | .111 | .190 | .074 | .824 | .033 | .156 |
| Proper product size | .090 | .203 | .047 | -.080 | .075 | .824 | .263 | .046 |
| Zoom in/out capability | .205 | .023 | .268 | .078 | .087 | .054 | .775 | .107 |
| Speed-up navigation capability | .181 | .089 | .005 | .262 | .129 | .242 | .718 | .056 |
| Direct searching for products | .109 | .117 | .063 | .071 | .235 | .210 | .138 | .793 |
| Cumulative Eigenvalue | 75.715 | | | | | | | |

Table 3 – Final interface features/elements and quality factors with their statistical values

| Online VR interface quality factor | No. of factors | Mean | SD. | Variance | Cronbach's Alpha | Priority Weight |
|---|---|---|---|---|---|---|
| **Atmospheric Experience** | **4** | **3.95** | **0.95** | **0.90** | **0.82** | **0.172** |
| Seasonal activities | | 4.11 | 0.95 | 0.90 | | 0.318 |
| Cashier's counter | | 3.92 | 0.86 | 0.74 | | 0.182 |
| Event synchronization | | 3.91 | 1.03 | 1.06 | | 0.322 |
| Elevator | | 3.84 | 0.94 | 0.89 | | 0.178 |
| **Content Finding**[a] | | | | | | **0.142** |
| Direct searching for products | | 4.03 | 0.90 | 0.81 | | 1.000 |
| **Decorative Elements** | **3** | **3.82** | **0.96** | **0.85** | **0.68** | **0.134** |
| Innovative elements | | 4.08 | 0.78 | 0.61 | | 0.342 |
| Decorative elements | | 3.90 | 0.91 | 0.84 | | 0.339 |
| Scenic viewpoints | | 3.46 | 1.06 | 1.13 | | 0.318 |
| **Place Familiarity** | **2** | **3.79** | **0.94** | **0.88** | **0.85** | **0.123** |
| Layout familiarity | | 3.85 | 0.95 | 0.91 | | 0.456 |
| Product department familiarity | | 3.72 | 0.94 | 0.87 | | 0.544 |
| **Standard Appearance** | **3** | **4.00** | **0.81** | **0.64** | **0.71** | **0.119** |
| Proper use of colors | | 4.16 | 0.76 | 0.58 | | 0.266 |
| Proper use of fonts | | 3.94 | 0.79 | 0.62 | | 0.215 |
| Layout customization | | 3.90 | 0.85 | 0.72 | | 0.519 |
| **Aspect Fit** | **2** | **4.26** | **0.73** | **0.52** | **0.75** | **0.116** |
| Proper product size | | 4.32 | 0.70 | 0.46 | | 0.358 |
| Proper use of camera's view | | 4.19 | 0.75 | 0.56 | | 0.642 |
| **Acceleration Capability** | **2** | **4.06** | **0.86** | **0.72** | **0.66** | **0.097** |
| Zoom in/out capability | | 4.14 | 0.83 | 0.69 | | 0.416 |
| Speed-up navigation capability | | 3.96 | 0.89 | 0.79 | | 0.584 |
| **Basic Virtual Reality Experience** | **3** | **4.29** | **0.86** | **0.74** | **0.71** | **0.096** |
| Overall reality | | 4.40 | 0.81 | 0.65 | | 0.262 |
| Touch screen interface capability | | 4.24 | 0.94 | 0.88 | | 0.373 |
| Animated elements | | 4.22 | 0.83 | 0.69 | | 0.365 |

[a]*Content Finding* is a one-item factor.

The inconsistency value is 0.01 or 1% indicating that the pairwise comparison consistency from the questionnaire was relatively high. Generally, the value should not exceed 0.1 or 10% [20]. The relative importance of quality factors are also presented as a bar chart in Figure 2.

The factor that was weighted highest in priority was *Atmospheric experience*, with a weight of 0.172 or 17.2%. The associated features/elements are: seasonal activities, cashier counter, event synchronization and elevator with weighted priorities within the factor of 31.8%, 18.2%, 32.2% and 17.8%, respectively. This factor might be one of the most unique features associated with VR interface, especially VR commerce interface. It also showed that *telepresense*, the sense of being there, was really exhibited as a unique feature in VR interface. Moreover, not only the *sense of being there* was important, in this study, it was interesting to discover that VR commerce users attached their *time* into the interface. They synchronized their period of the year expecting real-world event-synchronized treatments from the VR commerce store. It was clear that in adopting VR commerce interface, VR commerce stores have to offer shopping experience that was as close as what the shoppers experience in the real physical store.

The factor with the second highest priority is *Content finding tool* with a weight of 14.2%. Although it is a one item factor, we kept this factor as it was also perceived as important one; the relative weighted priority also confirmed this. Good VR commerce interface should try to come up with powerful tools to

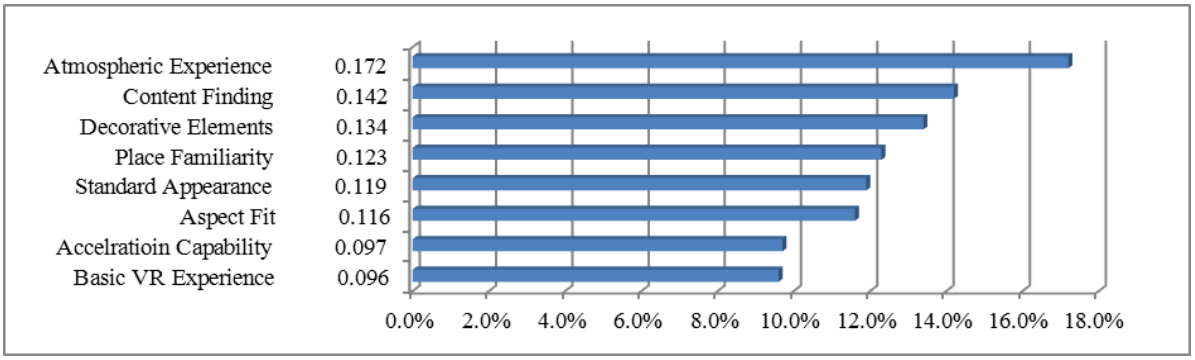


Figure 2 – Weighted priority of the quality factors towards adoption of VR Commerce for shopping. The inconsistency value is 0.01.

locate products.

The third factor is *Decorative elements* weighted 13.4%. The features/elements in this feature are: innovative elements, decorative elements and scenic view points with weighted priorities within the factor of 34.2%, 33.9% and 31.8%, respectively, which are quite equal. It was another feature that can attract users, mostly, emotionally. These aesthetic elements cannot be effectively implemented in standard 2D web interface as in VR. The result suggested that the existing of aesthetic elements was important in the VR interface acceptance.

The forth factor is *Place familiarity* with a weight of 12.3%. The features/elements in this feature are: layout familiarity and product department familiarity, which weighted within the factor quite equally, 45.6 and 54.4%, respectively. It was another unique feature of VR interface since the interface had capability to imitate and link itself to the real-world place. For marketing purposes, real-world stores can utilize benefits from this feature. The study of how VR might ease e-commerce user regarding their memory and cognitive effort on spatial activities could be explored.

The fifth factor is *Standard appearance* weighted by 11.9%. The associated features/elements are: proper use of colors, proper use of fonts, and layout customization which were weighted 26.6%, 21.5% and 51.9%, respectively. It was the standard factor dealing with proper use of visual elements for the purpose of function and aesthetic. As expected, this emerging factor was aligned with other studies regarding user interface quality factors. The result suggested that even basic guidelines for interface should be carried for VR interface and it came at a standard priority, around the middle. It should be noted that proper use of fonts and colors were rated pretty equally, while layout customization was much higher.

The sixth factor is *Aspect fit* weighted 11.6%. The features/elements associated with this factor are: proper product size and proper use of camera's view with weights of 35.8% and 64.2% respectively. The user expected a VR interface that appropriately visualizes items to fit their eyes. The factor covered *Proper use of product size* and *Proper use of camera's view*, which we noticed that this visualization-fit characteristic dealt with the way the users try to capture 3D objects into their brain. The result suggested opportunity to explore about product and virtual world visualization.

The seventh, the second to last, factor, is *Acceleration capability* with a weight of 9.7%. The

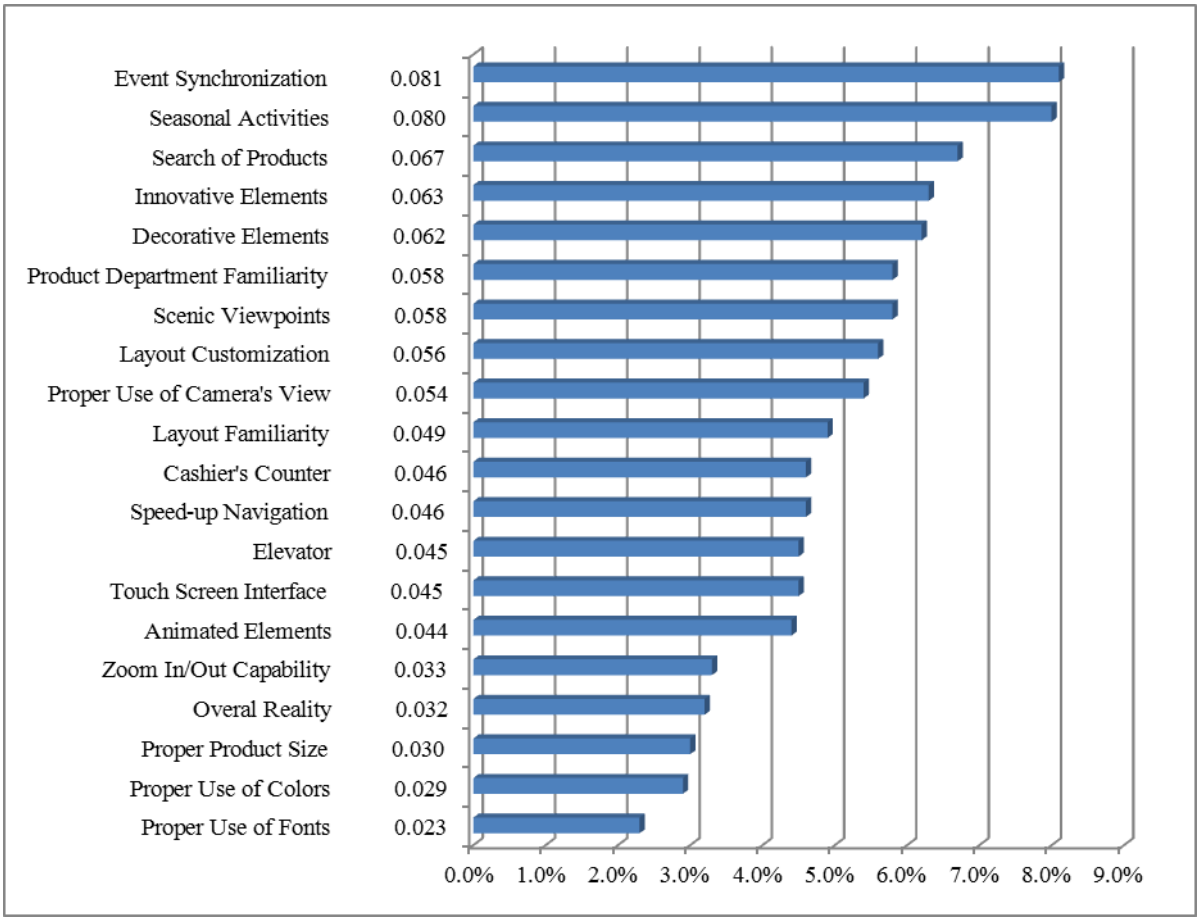


Figure 3 – Weighted priority of VR features/elements towards adoption of VR Commerce for shopping. The inconsistency value is 0.01.

features/elements associated with the factor are: zoom in/out and speed-up capability of the interface with weights of 41.6% and 58.4%, respectively. It indicated that users would like to speed-up the navigation sometimes. Although the use of navigation map did not make it into a member of the final stable factor of the study, it might gain importance if it is used to speed-up the navigation. Several other alternatives could be proposed to improve this factor of the interface.

The last factor is *Basic virtual reality experience* dealing with the basic experience that users expect in a VR interface with a weight of 9.6%. The features/elements associated with the factor are overall reality, touch screen interface capability and animated elements with weights of 26.2%, 37.3 and 36.5% respectively. By looking at a particular item in this most important factor, *Touch screen interface capability*, it suggested that the VR interface can be more widely adopted by implementing touch screen interface. The finding can be effortless to utilize since touch screens are becoming a more common household computer device, nowadays.

We further analyzed by examining the order of importance of items in the level of features/elements by pooling them all together. The top three of the most preferred items were *Event synchronization, Seasonal activities and Search for products*, respectively. The least important one for the VR adoption was the *Proper Use of Fonts*, as shown in Figure 3.

**Conclusion and Future Works**

This study was conducted to answer two research questions: 1) What were quality factors of the VR interface that users expected? and 2) What were the relative important orders of those quality factors for the adoption of the VR commerce interface? Based on the data collected from 144 IT undergraduate students in a university located in the northeastern of Thailand, we can conclude that there are eight quality factors of online VR commerce interface. The factors are: 1) *Basic virtual reality experience, 2) Aspect fit, 3) Acceleration capability, 4) Standard appearance, 5) Atmospheric experience, 6) Decorative elements, 7) Place familiarity and 8) Content finding tool.* The highest weighted factor is *Event synchronization;* the lowest weighted one is *Basic VR Experience.*

The finding can be utilized as guidelines for developing a good quality online VR commerce interface. Several areas can be further explored as discussed. Moreover, the work can be advanced to contribute further in developing a reliable instrument to evaluate this rich interface. The discovered factors can be studied on their impacts and applications on e-commerce, marketing, business purposes, and so on. Future studies can expand to cover other types of VR interface and the generalization of VR interface quality and usability.

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